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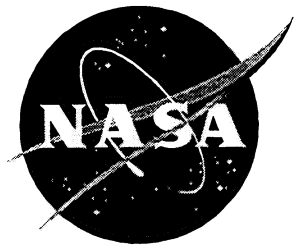

Survey Summary of AGATE Concepts Demonstration at Annual NATA Convention March 24-26, 1997

Volume I - Basic Report

Research Triangle Institute
Research Triangle Park, North Carolina

December 1997

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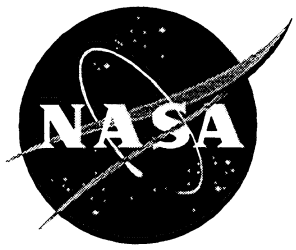

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National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23681-2199

Prepared for Langley Research Center
under Contract NAS1-19214

December 1997

Available from the following:

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Abstract

An AGATE Concepts Demonstration was conducted at the Annual National Air Transportation Association (NATA) Convention in 1997. Following a 5-minute introductory briefing, an interactive simulation of a single-pilot, single-engine aircraft was conducted. The participant was able to take off, fly a brief enroute segment, fly a Global Positioning System (GPS) approach and landing, and repeat the approach and landing segment. The participant was provided an advanced "highway-in-the-sky" presentation on both a simulated head-up display and on a large LCD head-down display to follow throughout the flight. A single-lever power control and display concept was also provided for control of the engine throughout the flight. A second head-down, multifunction display in the instrument panel provided a moving map display for navigation purposes and monitoring of the status of the aircraft's systems.

An estimated 100 people observed or participated in the demonstration and 68 surveys were collected. The pilot ratings of the participants ranged from student to Air Transport Rating with an average of 6089 hours total flight time. The performance of the participants was surprisingly good considering the minimal training in a completely new system concept. The overwhelming response was that technologies that simplify piloting tasks are enthusiastically welcomed by pilots of all experience levels. The increase in situation awareness and use of the head-up display were universally accepted and lauded as steps in the right direction.

Table of Contents

Volume I

Appendices

* Volume II

* Published under separate cover as NASA CR-201731, Volume II

Survey Summary
of
AGATE Concepts Demonstration
at Annual NATA Convention
March 24-26, 1997

Overview of AGATE Concepts Demonstration at 1997 NATA Convention

The AGATE Concept Demonstrator as depicted below was displayed at the Annual National Air Transportation Association (NATA) Convention in 1997. An estimated 100 people observed or participated in the demonstration and 68 surveys were collected. A voluntary survey instrument was completed by a majority of the demonstration participants at the conclusion of the demonstration. The survey instrument is found at Appendix A to this report.

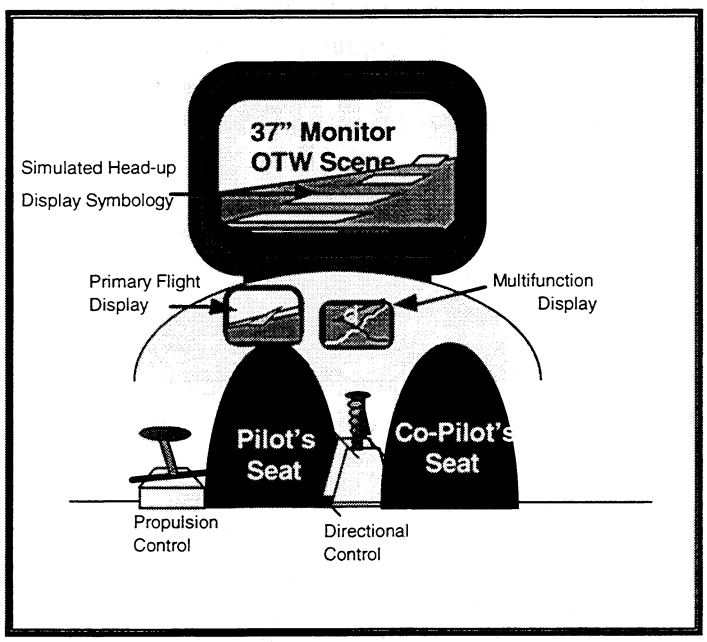

Figure 1 - Concept Demonstrator Configuration

The focus of the demonstration was on the concepts under investigation and development within the AGATE Project to enhance pilot situation awareness, to simplify the task of piloting an airplane, to reduce the time and cost of training, and to enhance the utility of the airplane as a transportation vehicle. Key concepts demonstrated included:

- integration of primary flight control information into a single electronic display (both head-up and head-down) using an intuitive perspective presentation with a "highway-in-the-sky" format
- integration into a single electronic display of navigation information and the information required to monitor and manage aircraft systems
- single-lever power control for the pilot
- single, integrated flight control device
- incorporation within the cockpit of the airplane of an embedded training system

The demonstration began with a ten minute overview of the AGATE Project, the operational concepts and supporting technologies to be demonstrated, and the demonstration scenario. The concept of use of computer-based automated training devices to facilitate pilot training was then demonstrated in a five minute overview of the AGATE display and control concepts to be used by the participants in the simulated flight demonstration.

One of the group of participants in a given demonstration period (there were typically 4-5 participants per 20-minute demonstration) was then invited to fly a four minute simulated flight scenario while the other participants observed the flight. The demonstration scenario consisted of a takeoff and departure from Denver International Airport in Colorado, level-off briefly at 2,500 feet AGL, and a GPS approach and landing at Buckley Field, Colorado. The simulation was then restarted at the beginning of the GPS approach and the participant reflew the approach and landing phases of the flight. At the conclusion of the demonstration, all participants were invited to complete a survey of their impressions.

The four minute simulated flight and the repeat of the approach and landing were presented to the participants as though they were using the "embedded trainer" feature of their AGATE airplane. The embedded trainer concept is one in which all systems of an aircraft except the engine are operated in a flight simulation mode prior to actual flight as a means to rehearse and train for an upcoming flight.

The AGATE demonstration pilots showing the concepts to the NATA participants observed that overall performance of the participants was surprisingly good considering the minimal training in a completely new system. The overwhelming response of the participants was that technologies that simplify piloting tasks are enthusiastically welcomed by pilots of all experience levels. The increase in situation awareness and reduction in pilot workload were universally accepted and lauded as steps that are definitely in the right direction. The popular choice is simplification.

The ease with which the participants flew the demonstrator may be in part attributed to the pre-brief they each received. This pre-brief covered the simulated flight scenario with scenes from the simulation used as examples of what they would encounter during their flight. Also, most individuals had much more confidence in their ability to fly the demonstrator when they repeated the approach and landing as part of the embedded training scenario. This indicates the ease with which an individual is likely to adapt to the new technology and functionality of the AGATE aircraft.

Significant Characteristics of Demonstration Participants

The participants in the AGATE Concepts Demonstration at NATA exhibited the following characteristics as evidenced by their answers to the questions on the survey form:

The total number of respondents	68
Individuals that flew demonstrator	52
Individuals that observed demonstrator	16
The average flight hours in the last 12 months	244
The average total flight hours in GA aircraft	6089
The number of flight instructors	25
The number of people owning/managing FBOs	27
Of FBOs the number of Part 61 operators	12
Of FBOs the number of Part 141 operators	9
The type of training provided by flight schools:	
Private Pilot	26
Commercial Pilot	25
Instrument Rating	25
ATP	21
CFI	22
The average GA airplanes in businesses	16
The average hours on a/c per year	1142

The distribution of ratings among the respondents is depicted in Figure 2 below.

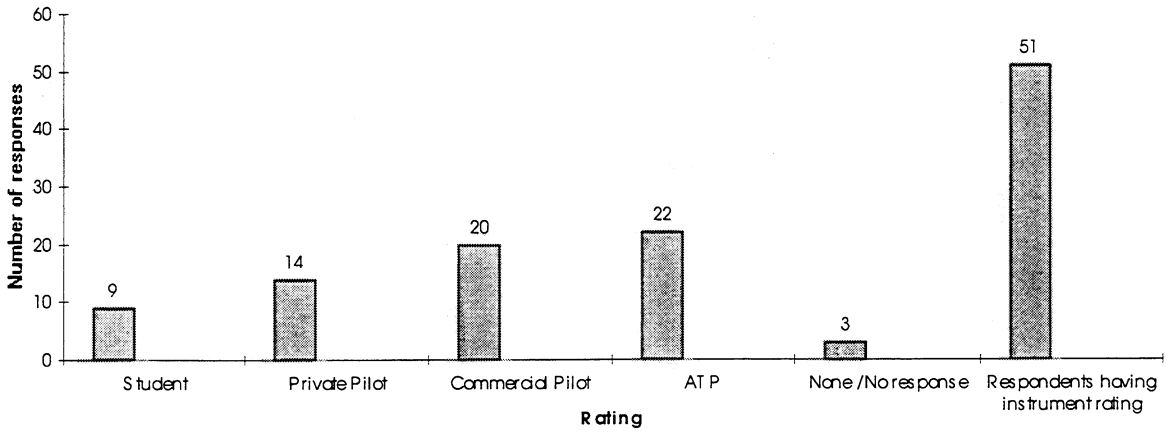

Figure 2 - Pilot Ratings of Survey Respondents

The main type of aircraft flown by the respondent (or by the respondent's business) is depicted in Figure 3 below.

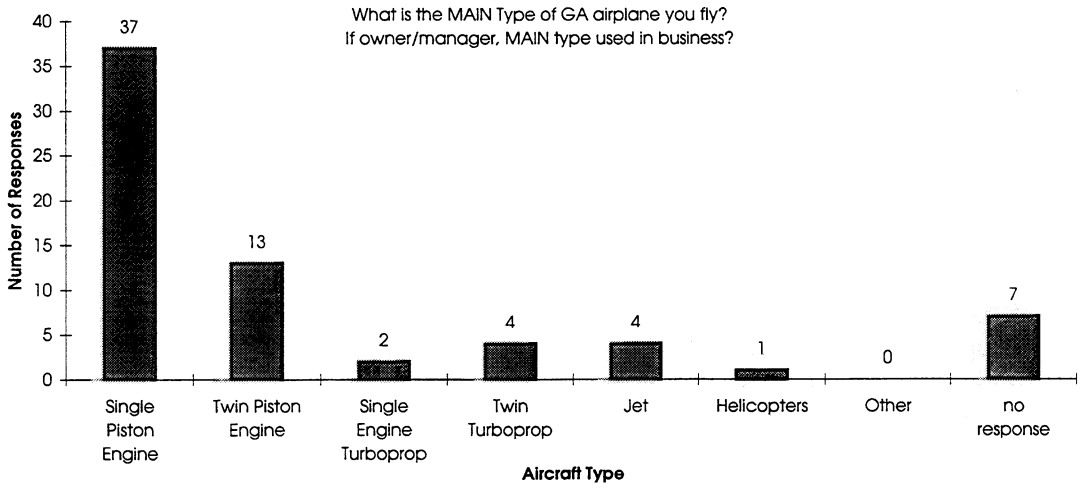

Figure 3 - Main Type Aircraft Flown/Operated

The primary business activities of the respondents according to their survey responses (question 14) are depicted in Figure 4 below.

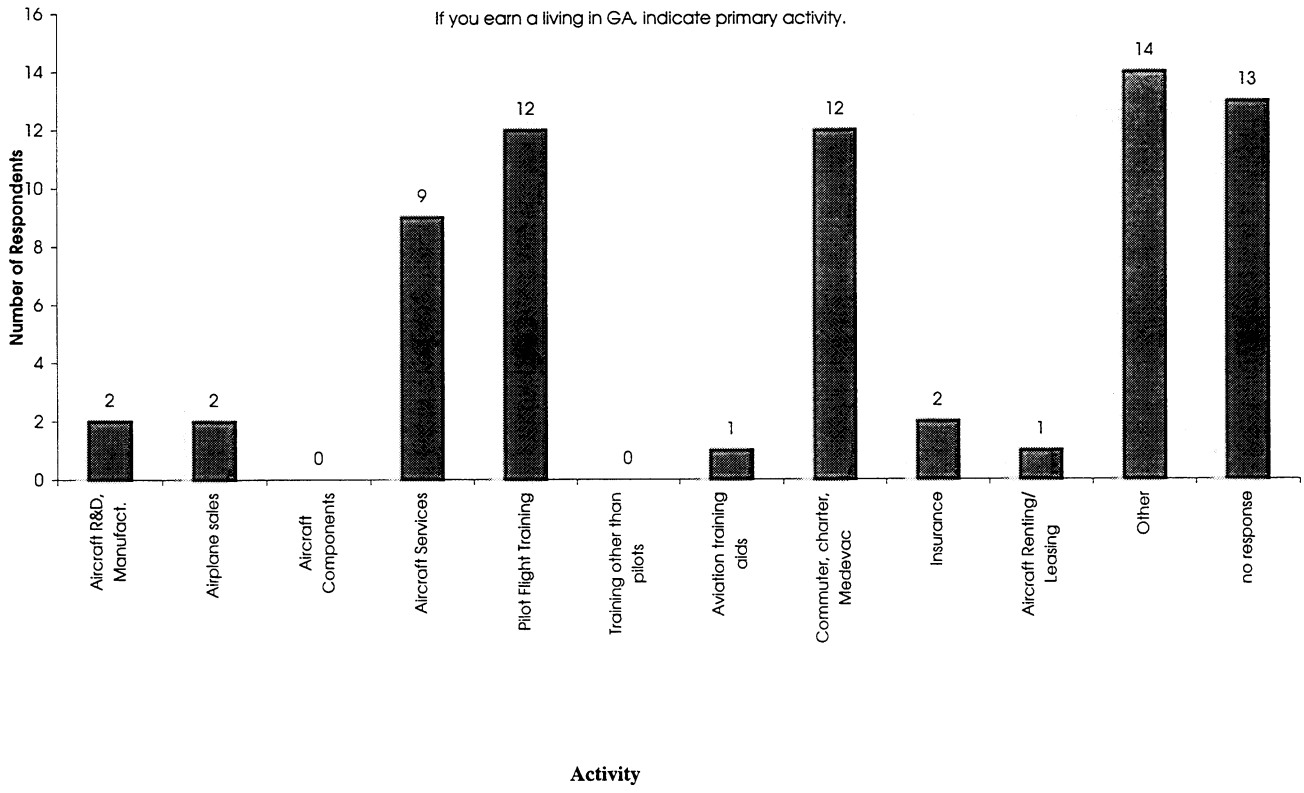

Figure 4 - Primary Business Activity

Survey Responses to AGATE Technology Questions

The anticipated effect of the implementation of the capabilities demonstrated on the respondents' use rate of their aircraft (question 12) is depicted in Figure 5 below.

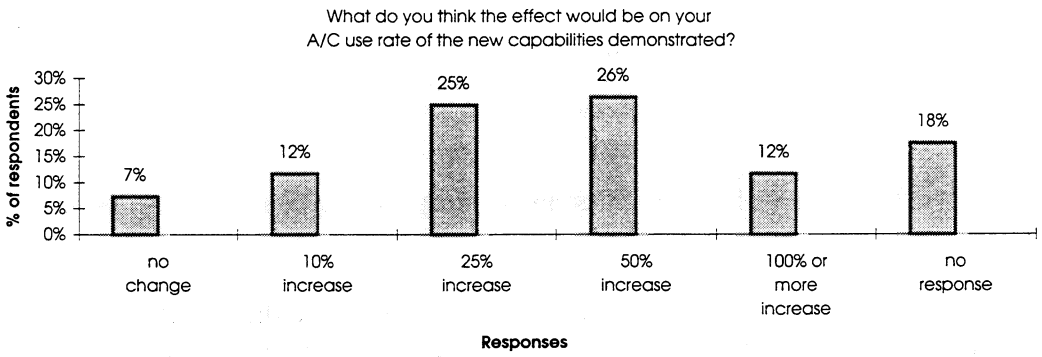

Figure 5 - Effect of AGATE Capabilities on Respondent's Use Rate of Their Aircraft

In their response to the question of the extent to which the concepts demonstrated are likely to change the pilot's situational awareness (question 16), 93% of the respondents indicated that it would increase either somewhat or greatly. Five percent indicated that it would reduce, and 1% did not answer the question. These responses are depicted in Figure 6 below.

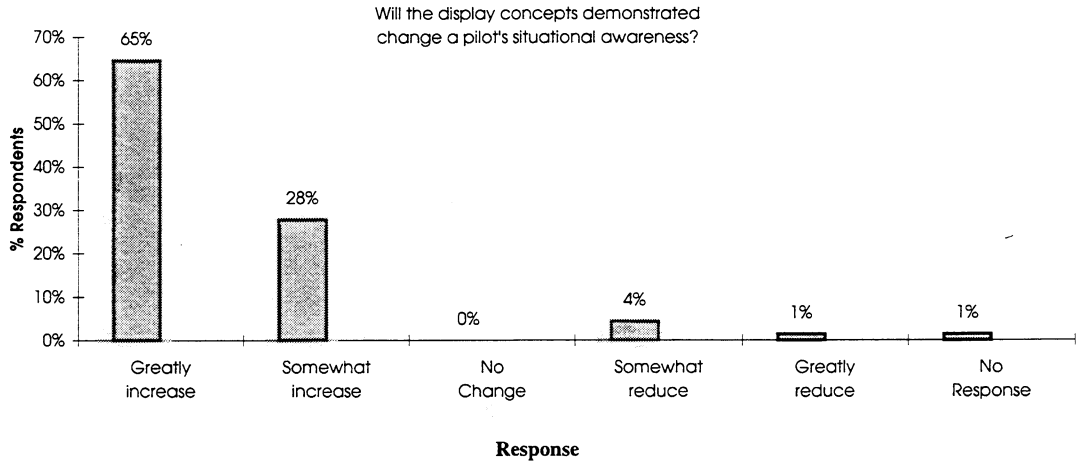

Figure 6 - Effect of Demonstrated Display Concepts On Situation Awareness

When questioned about the value of the "Head-Up" display concept compared to current GA displays (question 17), 97% indicated it would increase the value, 1% said there would be no change, and there were no responses indicating it would be of less value. These responses are depicted in Figure 7.

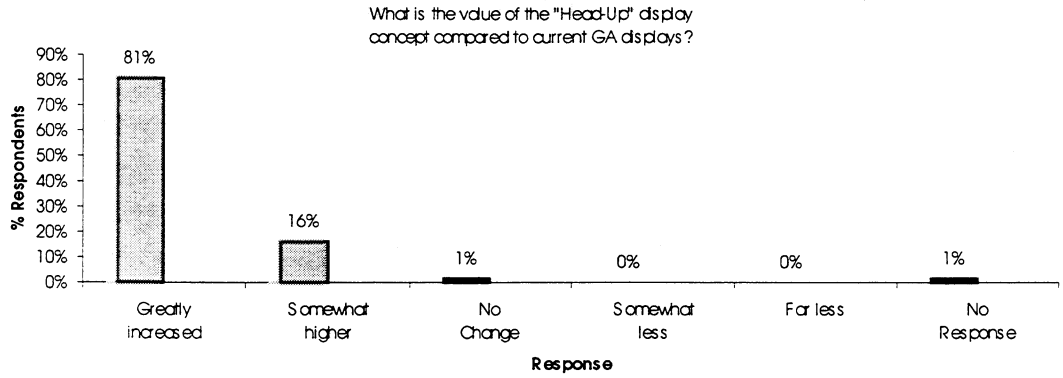

Figure 7 - Value of Head-Up Displays Compared to Current GA Displays

The concept of the "Highway-in-the-sky" graphic depiction of the flight path received rave reviews (question 18) with all but one of the respondents indicating that it made the pilot's tasks easier, and with that one saying that it would make no difference. Of the concepts demonstrated, the "Highway-in-the-sky" concept received the highest score indicating a high degree of acceptance by the demonstrator participants. The responses are depicted in Figure 8 below.

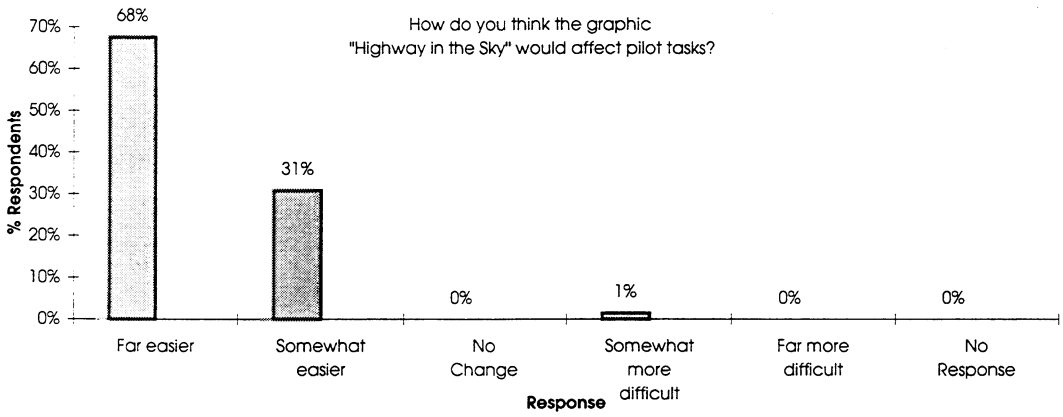

Figure 8 - Effect of "Highway-in-the-Sky Display on Pilot Tasks

Approximately 65% of the respondents indicated that they do not currently use any personal computer-based automated training devices (question 19) as indicated in Figure 9. Of the individuals who do use the devices, the majority use them for instrument training and for retaining their personal proficiency (question 20) as indicated in Figure 10. Ninety-five percent of the respondents believe that personal computer-based automated training devices (PCATD) would be more effective than the current methods of providing information and skills (question 21) as indicated in Figure 11. Ninety-nine percent felt that the use of PCATDs would make getting a new rating faster (question 22) as indicated in Figure 12.

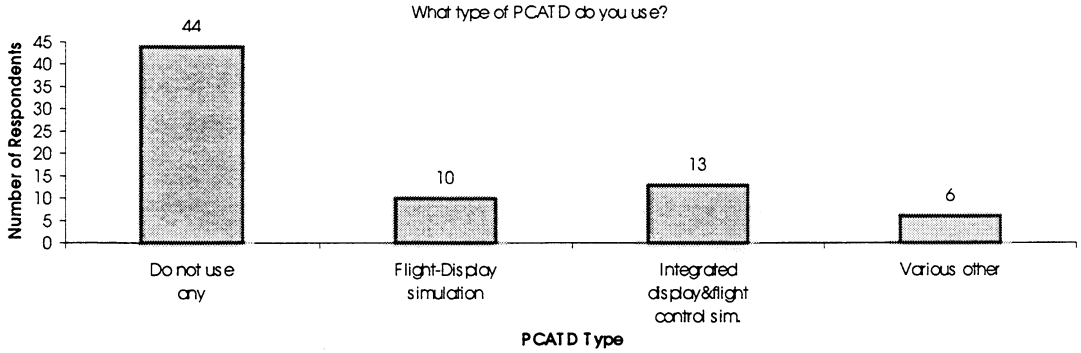

Figure 9 - Type of PCATD Used

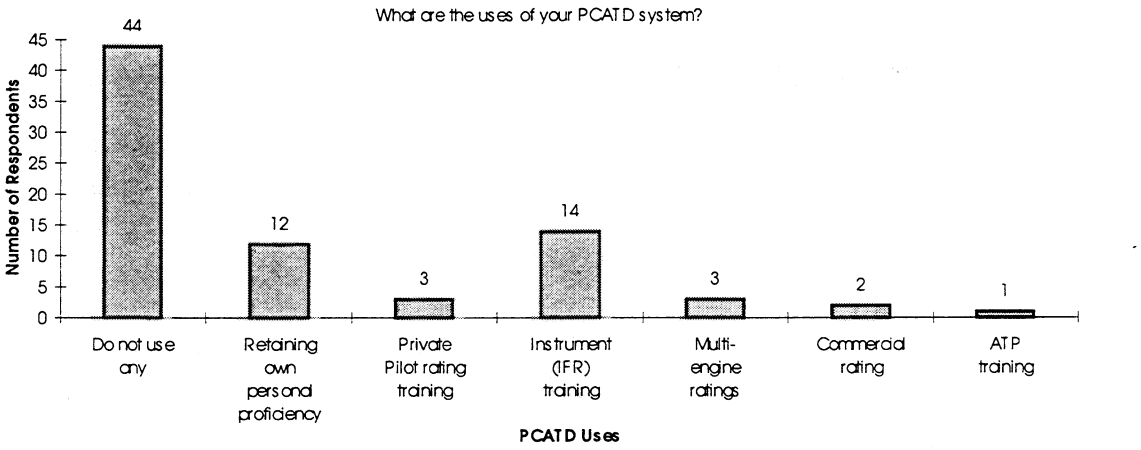

Figure 10 - Current Uses of PCATD Systems

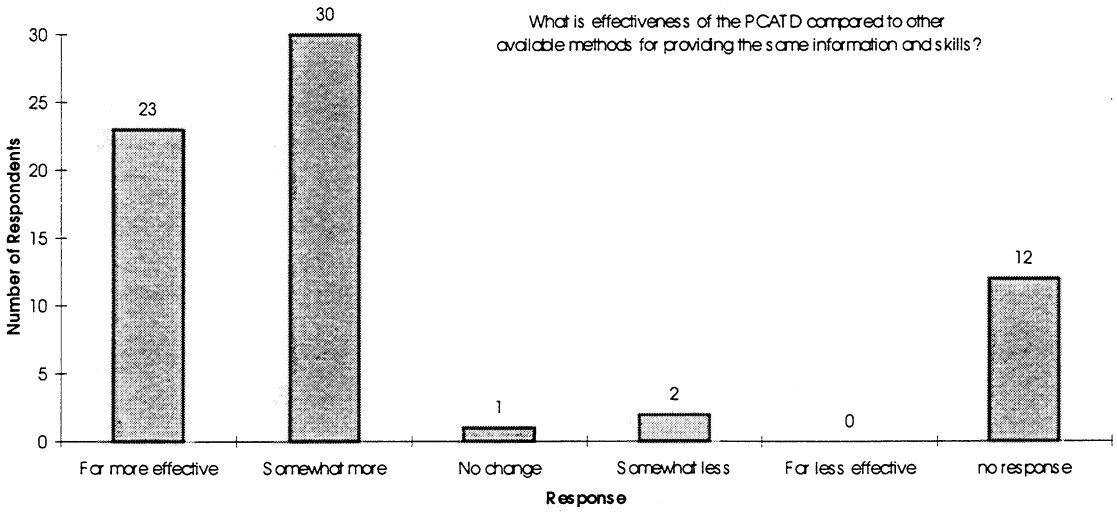

Figure 11 - Estimated Effectiveness of PCATD Compared to Other Available Training Methods

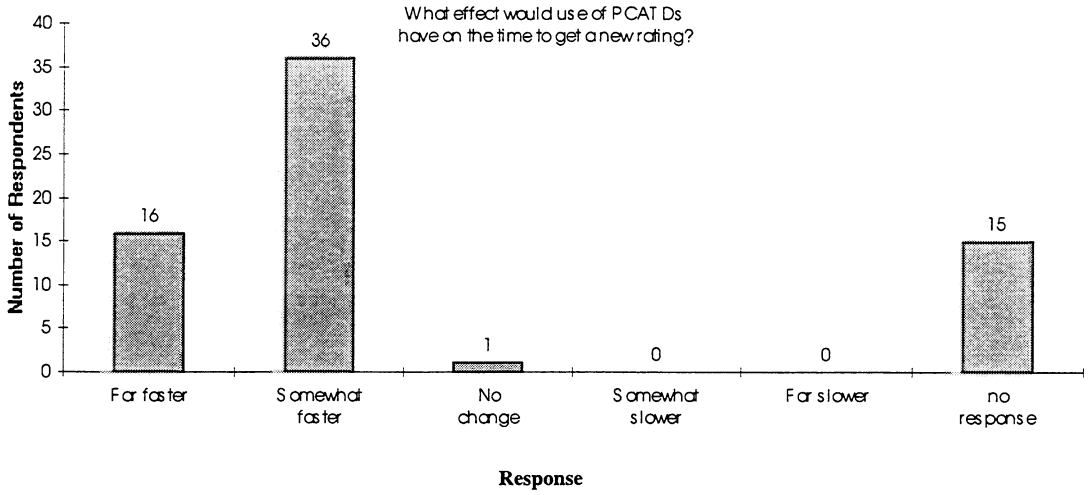

Figure 12 - Estimated Effect of PCATD on Time to New Rating

Fifty percent of the individuals responding to the questionnaire regarded the current situation of "no credit toward flight ratings" as a major obstacle to their wider use of PCATDs (question 23) as indicated in Figure 13 below. Forty percent indicated their complexity is a major concern, while 22% said that home computer costs and the lack of realism were major concerns.

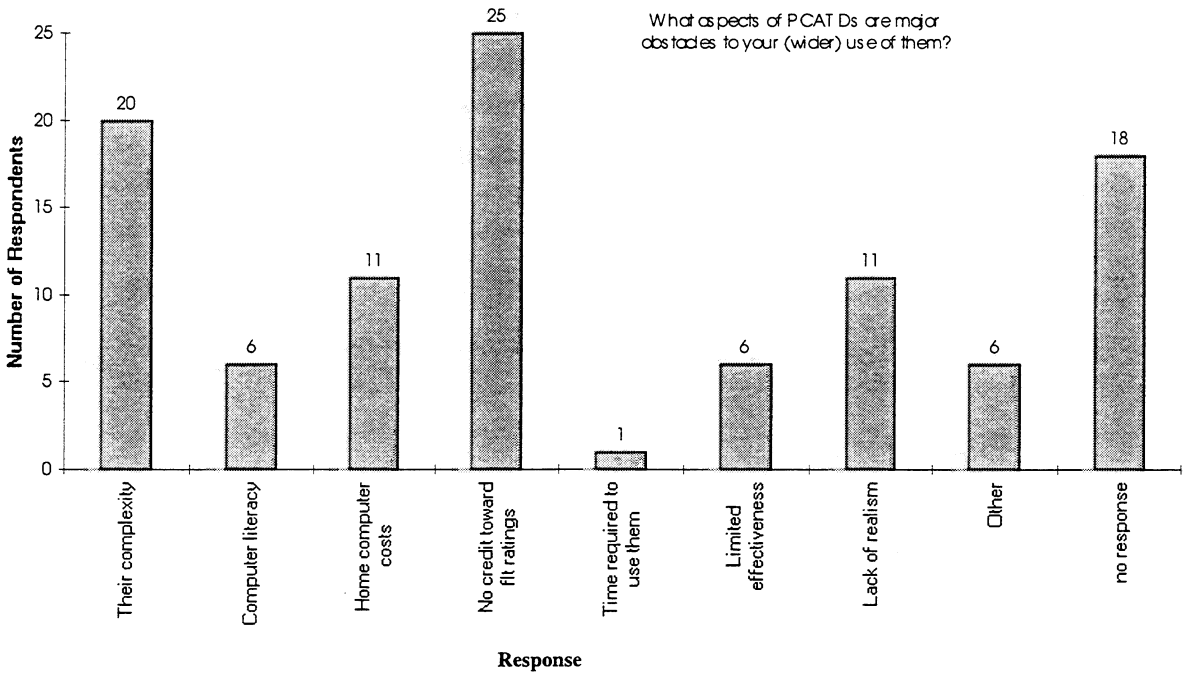

Figure 13 - Current Obstacles to Use of PCATDs

Participants were asked to identify the likely training value for selected flight operations of the "embedded training" concept in which the actual AGATE aircraft cockpit would be used as a ground flight simulator (question 24). Their responses are depicted in Figure 14.

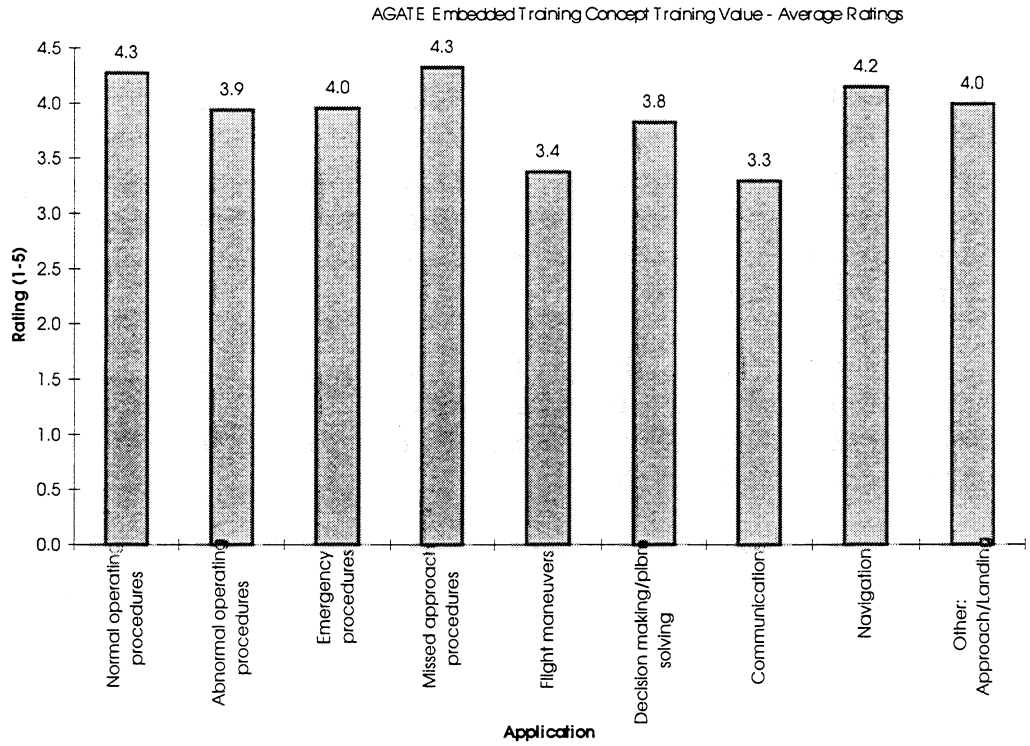

Figure 14 - Estimated Value of AGATE Embedded Training System Concept for Selected Applications

Finally, participants were asked to rate the likely importance of the AGATE capabilities demonstrated in the AGATE Concepts Demonstration (question 25). Their responses are depicted in Figure 15 below.

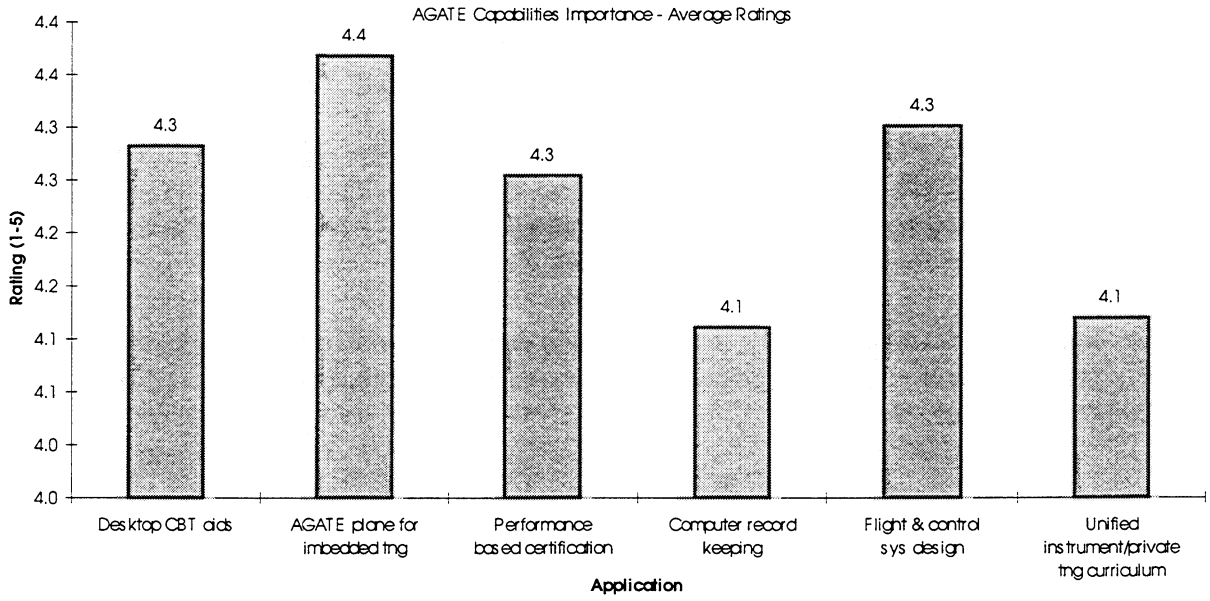

Figure 15 - Estimated Importance of AGATE Capabilities

Summary of Comments of Demonstration Respondents

Questions 26, 27 and 28 of the questionnaire asked the participants for further comments regarding the value of the AGATE concepts demonstrated. A summary of the respondents' comments is provided below. The individual responses of the respondents to each of the questions are provided in Appendix B.

Concerning the question of increased situational awareness (question 26):

82% had comments or answers that were positive
13% said they either did not know or predicted a decrease in awareness
4% indicated they foresaw no change

Typical comments in answering this question were:

- "Increase, head-up display allows pilot to look up, rather than down at instruments"
- "Easier to keep track of where you are"
- "Essential information presented in an easier format. Average pilot workload is greatly reduced"
- "Clearer mental picture of what is happening in 3D. Less mental gymnastics/arithmetic"

Concerning the question of the concept demonstrated having the most value to GA pilot (question 27):

35% indicated the simplicity of flight
22% indicated the Highway in the Sky
15% indicated the H.U.D.
11% indicated reduction in workload
8% showed cost and safety as the major factor
7% indicated the integrated controls and single-lever power control

Typical comments in answering this question were:

- "Integrated controls and single lever control - simpler - tells you where you should be"
- "Highway in the Sky concept, head-up display, workload reduction"
- "Visualization in low-visibility situations"
- "Simplicity of operation. Less systems managing"

The comments of the respondents to this question were evenly distributed about the concept demonstrator features. Items repeatedly mentioned included the head-up display, the highway-in-the-sky format, and the SLPC.

Concerning the question of the concept demonstrated having the least value to GA pilots (question 28):

21% indicated no least value, that all looked good
15% where not sure
12% were concerned about the over-simplification of procedures
9% each for the use auto-coordination of rudder/ailerons and the "over use" of technology

6% thought that the cost would be a large deterrent
30% indicated various concerns such as:
communications
safety
the simulator does not fly like a real plane
attitude display

Typical comments of respondents in answering this question were:

- "None, very good"
- "The absence of rudders, etc., auto power settings. Pilots will loose or not gain valuable flight techniques"
- "Auto flaps, loss of 'numbers' based training"
- "This will make pilots less aware of the airway system like GPS and LORAN has done to XC pilots"

APPENDIX A

AGATE Concepts Demonstration Survey Questionnaire

AGATE Concepts Demonstrator Survey

NATA Convention, March 24-26, 1997

- Please provide only one answer (the most important one) to each question, unless requested otherwise.
- Leave a question blank if it does not apply or if you do not know the answer.

1. Where do you live? (State's Initials) _____

2. What is your highest flight rating?
   1 ❑ Student
   2 ❑ Private Pilot
   3 ❑ Commercial Pilot
   4 ❑ ATP

3. Do you have an instrument rating?
   1 ❑ Yes
   2 ❑ No

4. How many hours did you fly as a pilot in general aviation airplanes in the last 12 months? _____

5. Enter your total pilot flying hours in GA airplanes? _____

6. Are you a flight instructor now?
   1 ❑ Yes
   2 ❑ No

7. Do you own or manage an FBO?
   1 ❑ Yes
   2 ❑ No

8. If you own or manage a flight school, check type:
   1 ❑ Part 61
   2 ❑ Part 141

9. Check ratings, if any, for which you provide flight training. Applies to your organization if you own or manage a flight school: (Check all)
   1 ❑ Private Pilot
   2 ❑ Commercial Pilot
   3 ❑ Instrument Rating
   4 ❑ ATP
   5 ❑ CFI

10. How many general aviation airplanes does your business have? _____

11. How many hours do you fly on your aircraft per year? _____

12. What do you think the effect would be on your A/C use rate of the new capabilities you have seen demonstrated today?
   1 ❑ no change
   2 ❑ 10% increase
   3 ❑ 25% increase
   4 ❑ 50% increase
   5 ❑ 100% or more increase

13. What is the main type of general aviation airplane you fly? If you are the owner or manager, indicate the main airplane type used in your aviation business
   1 ❑ Single Piston Engine
   2 ❑ Twin Piston Engine
   3 ❑ Single Engine Turboprop
   4 ❑ Twin Turboprop
   5 ❑ Jet
   6 ❑ Helicopters
   7 ❑ Other _____

14. If you earn a living in general aviation, state the primary activity you are engaged in. (Check only one)
   1 ❑ Aircraft R&D, Manufact.
   2 ❑ Airplane sales
   3 ❑ Aircraft components
   4 ❑ Aircraft services
   5 ❑ Pilot flight training
   6 ❑ Training other than pilots
   7 ❑ Aviation training aids
   8 ❑ Commuter, charter, Medevac or air taxi
   9 ❑ Insurance
   10 ❑ Aircraft renting or leasing
   11 ❑ Other: _____

15. How did you take part in the AGATE concept demonstration?
   1 ❑ "Flew" demonstrator"
   2 ❑ Observed

16. Will the display concepts demonstrated change a pilot's situation awareness?
   1 ❑ Greatly increase it
   2 ❑ Somewhat increase it
   3 ❑ No change
   4 ❑ Somewhat reduce it
   5 ❑ Greatly reduce it

17. What is the value of the "Heads-Up" display concept compared to current GA displays?
   1 ❑ Greatly increased value
   2 ❑ Somewhat higher value
   3 ❑ No change
   4 ❑ Somewhat less value
   5 ❑ Far less value

18. How do you think the graphic "Highway in the Sky" would affect pilot tasks?
   1 ❑ Far easier
   2 ❑ Somewhat easier
   3 ❑ No change
   4 ❑ Somewhat more difficult
   5 ❑ Far more difficult

19. What kind of desktop personal computer-based flight training aids, if any, do you use for flight training or to maintain proficiency? (Check all that apply)
   1 ❑ Do not use any
   2 ❑ Flight-display simulation
   3 ❑ Integrated display & flight control simulations
   4 ❑ Various other individual piloting & A/C systems

20. List your uses of desktop computer-based flight training aids (All)
    1 ❑ Do not use any
    2 ❑ Retaining own personal proficiency
    3 ❑ Private Pilot rating training
    4 ❑ Instrument (IFR) training
    5 ❑ Multi-engine ratings
    6 ❑ Commercial rating
    7 ❑ ATP training

21. In your opinion, what is the effectiveness of these computer-based flight training aids compared to other available methods for providing the same information and skills. (Check one)
    1 ❑ Far more effective
    2 ❑ Somewhat more
    3 ❑ No change
    4 ❑ Somewhat less
    5 ❑ Far less effective

22. What effect do these desktop computer-based flight training aids have on the time (calendar) to get a new rating.
    1 ❑ Far faster
    2 ❑ Somewhat faster
    3 ❑ No change
    4 ❑ Somewhat slower
    5 ❑ Far slower

23. What aspects of desktop computer-based flight training aids are major obstacles to your (wider) use of them. (all)
    1 ❑ Their complexity
    2 ❑ Computer literacy
    3 ❑ Home computer costs
    4 ❑ No credit toward Flt. ratings
    5 ❑ Time required to use them
    6 ❑ Limited effectiveness
    7 ❑ Lack of realism
    8 ❑ Other: _____

24. Rate the likely training value of using the actual AGATE airplane cockpit as a ground flight simulator. Enter any rating from 1 = little value to 5 = very great value for each item below. Duplicate ratings are allowed. Do <u>not</u> rank in order.

    __ Normal operating procedures

    __ Abnormal operating Proceed.

    __ Emergency procedures

    __ Missed approach procedures

    __ Flt. maneuvers (e.g., stalls, etc)

    __ Decision making & problem solving

    __ Communications

    __ Navigation

    __ Other: _____

25. Based on the demonstration, rate the likely importance of the following capabilities expected from the AGATE program. Enter any rating from 1 = little value to 5 = very great value for each item below. Duplicate ratings are allowed. Do <u>not</u> rank in order,

    __ Desktop computer-based training aids for pilots and technician training

    __ Use of AGATE airplane cockpit as ground flight simulator

    __ Performance-based certification, instead of set flight time requirements

    __ Computer record keeping for pilot training and certification

    __ Flight and control system design to simplify pilot tasks and training

    __ Unified instrument/private pilot training curriculum

26. Why do you think the AGATE display concepts would cause the pilot's situation awareness to improve, decrease or remain the same.

27. What concepts presented in the AGATE Demonstrator do you believe offer the <u>most</u> value to a general aviation pilot? Why?

28. What concepts presented in the Demonstrator do you believe offer the least value to a general aviation pilot? Why?

"Thank you for your important insights."

APPENDIX B

AGATE Concepts Demonstration Survey Data Summary

Data Summary Sheet
Questions 1-25

Question:	Responses:	
1	1	AK
	3	CA
	1	CO
	1	CT
	25	FL
	2	GA
	1	IA
	3	IL
	1	MD
	1	ME
	4	MI
	1	MN
	3	MO
	1	NC
	5	NJ
	5	NY
	2	OH
	1	PA
	1	TX
	2	UT
	1	VA
	1	WI
2	9	Student
	14	Private Pilot
	20	Commercial Pilot
	22	ATP
	3	No Response
3	51	Yes
	17	No
4	26	< 50
	9	50 to 100
	6	100 to 200
	18	200 to 500
	9	> 500
5	13	< 100
	9	100 to 500
	9	500 to 1000
	16	1000 to 5000
	21	> 5000

Question:	Responses:	
6	25	Yes
	43	No
7	27	Yes
	41	No
8	12	Part 61
	9	Part 141
	47	No response
9	26	Private
	25	Commercial
	25	Instrument
	21	ATP
	22	CFI
10	29	< 10
	31	10 to 25
	4	26 to 50
	2	51 to 75
	2	> 75
11	10	< 100
	39	100 to 500
	8	500 to 1000
	7	1000 to 5000
	4	> 5000
12	5	1
	8	2
	17	3
	18	4
	8	5
	12	No response
13	37	1
	13	2
	2	3
	4	4
	4	5
	1	6
	0	7
	7	No response

Question:	Responses:	
14	2	1
	2	2
	0	3
	9	4
	12	5
	0	6
	1	7
	12	8
	2	9
	1	10
	14	11
	13	No response
15	52	Flew
	16	Observed
16	44	1
	19	2
	0	3
	3	4
	1	5
	1	No response
17	55	1
	11	2
	1	3
	0	4
	0	5
	1	No response
18	46	1
	21	2
	0	3
	1	4
	0	5
	0	No response
19	44	1
	10	2
	13	3
	6	4

Question:	Responses:	
20	44	1
	12	2
	3	3
	14	4
	3	5
	2	6
	1	7
21	23	1
	30	2
	1	3
	2	4
	0	5
	12	No response
22	16	1
	36	2
	1	3
	0	4
	0	5
	15	No response
23	20	1
	6	2
	11	3
	25	4
	1	5
	6	6
	11	7
	6	8
	18	No response

24

RATINGS	0	1	2	3	4	5
Normal	12	0	4	7	13	30
Abnormal	16	0	6	13	8	22
Emergency	16	1	6	10	9	23
Missed	17	0	0	10	13	26
Flt maneuvers	17	4	9	12	9	13
Decision	16	2	6	11	8	21
Communications	18	6	8	9	7	13
Navigation	17	2	3	6	10	25
Other	0	0	0	0	0	0

25

RATINGS	0	1	2	3	4	5
Desktop	11	1	3	8	9	32
Use of	8	0	4	6	12	35
Performance	14	4	1	5	9	32
Computer	12	3	3	8	11	29
Flight	12	0	4	7	11	31
Unified	13	0	3	13	9	25

Responses to Question 26

Why do you think the AGATE display concepts would cause the pilot's situation awareness to improve, decrease or remain the same?

- It would increase for low-time pilots and remain the same for high-time pilots
- Increase
- Improve
- Improve
- Increase
- Workload
- Decrease thru complacency
- Same
- Increase, head-up display allows pilot to look up, rather than down at instruments
- Would increase due to information being available in manner that is logical and easily accessible
- "Can" help pilots "visualize" situation, can assist in teaching positional awareness.
- Can concentrate on most critical problems first
- Improve
- Everything is displayed so pilot would always be aware - one less thing to think about
- Not sure
- Immediate visual concept - more accurate response
- Improve
- Easier to keep track of where you are
- Improve because of the easiness to make correcting and situation awareness.

Responses to question 26 (Continued)

- Simple, lower cost to maintain
- Narrows the focus of concentration.
- Remain the same. What do you do if you have a computer failure in flight?
- I am not sure, it depends on what other information the pilot has to use.
- Heads up, realistic display
- By displaying flight path as a geographic concept instead of a nav signal geometric concept, the average pilot could grasp it far better
- Visually (HUD) based system will improve situational awareness
- It would improve due to constant position updates
- Graphic display of terrain and desired flight path - especially in head-up display
- You can practice the approach
- Distraction in cruise Great for approach
- Improve, No man-made distractions
- AGATE Display would improve awareness
- Improve
- Decrease in actuality
- Decrease
- Essential information presented in an easier format. Average pilot workload is greatly reduced.
- Allow more time to train that is cost effective Practice = greater S.A.
- Improve
- Intuitive visual cues will positively improve
- Clearer mental picture of what is happening in 3-D. Less mental gymnnastics/arithmetic.

Responses to question 26 (Continued)

- By providing flight guidance cues in the contact scene which match "plan view" map imagery, @ least the heightened awareness of position may be realized

- The MFD helps the pilot to realize exactly where he is - something that currently takes a great deal of thought. Also, the simulator helps to keep the pilot on course with less deviations

- Because the display is continuous, without numbers, you are forced to watch it move, prolonging the division of your attention between panel and outside the airplane

- Heads-up display & your position displayed

- It takes complicated data and groups it into info that is user friendly

- Improve them but they could be improved more if attention was paided H.F.E. research in the area. I.E. Velocity vector should ALWAYS be used -- No attitude!

Responses to question 27

What concepts presented in the AGATE Demonstrator do you believe offer the <u>most</u> value to a general aviation pilot? Why?

- Integrated controls and single-lever control - simpler - tells you where you should be.
- Ease of flying - improved safety
- Simplicity
- Introduction to flight, reduction in training cost
- Easier
- The display of vital information
- Highway in the sky concept, heads-up display, workload reduction
- Visual representation of desired flight path, standardization of technique
- H.U.D
- Highway in the sky and road signs
- Computer assisted decision making
- 1st visual, 2nd single control
- Highway signs
- Computer aided flight planner - the highway in the sky will help you navigate much easier
- Pathway in the sky and unified joystick and single speed lever. Easier to fly.
- Higher levels of safety. Less cockpit confusion
- Visualization in low visibility situations
- A cheaper overall cost. Get more people involved.
- Simplified cockpit, lower workload
- HUD, able to see through weather. Vol. Indication on HUD

Responses to question 27 (Continued)

- Single unified display
- Highway in sky. Situational awareness. Major concern: Reliability - an AGATE trained pilot in a loss of data/display would have no situational awareness.
- Integrating cockpit displays and training methods
- The ease of flying. Takes away the complexity.
- Flight path mapping and terrain presentation
- Tracking and approach
- IFR approach
- Very easy to learn
- HUD
- Heads up always is better
- Simplicity you don't need to understand why only follow the path and directions
- Simplifications
- Simplicity of operation. Less systems managing
- Simplicity
- Demonstration of how simpler operation and greater reliability will result from continuation of AGATE program
- The ability to turn night IMC into day VMC is intriguing. The natural cues we use to maintain orientation & establish position inflight w/respect to ground references become available All the time & no more hieroglyphics (sa!)!!
- Highway in the sky - easy to follow a route. Simplification - almost anyone can do it!
- It allows much more precise approaches and it is good for navigation. You don't have to constantly check your waypoints and directional indicator.
- Safety and increased learning time.
- Improved display of basic flight info significantly reduce pilot workload

Responses to question 28

What concepts presented in the AGATE Demonstrator do you believe offer the <u>least</u> value to a general aviation pilot? Why?

- None - very good
- ?
- Need capability to fly without system
- Automatic turn coordination
- Safer
- The absence of rudders, etc. auto power settings. Pilot's will loose or not gain valuable flight techniques.
- ?
- Over reliance on technology vs. flying skills
- None now - need time to think!
- Not sure
- No concept - but cost & trouble with implementation. What happens if learn proficiency with this concept , then step back to 1940's instrument flying??
- ?
- The price may be big.
- It does not fly like a plane
- Emergency procedures
- Auto flaps, loss of "numbers" based training
- Single lever power control. I would rank this as nice to have but not too big a deal.
- The fundamentals of flying

Responses to question 28 (Continued)

- Putting the technology in the actual airplane for "rehearsing" flights. The home sim would do as well.
- Trim tab
- Cruise guidance seems unnecessary
- Cost???? FAA implementation
- None, it all can improve GA safety
- None, everything seemed to work together with me, the pilot
- Lack of real world reality - almost a game like atmosphere - what happens if equipment fails?
- This will make pilots less aware of the airway system like GPS and LORAN has done to XC Pilots.
- Any system that makes for a safer pilot has great value for a GA pilot.
- They all look great!
- Demonstrator is not particularly helpful for learning/practicing flight in existing aircraft. Let's get the new generation built. So we have something to practice for.
- The engine & system monitoring seems on first blush to be more complex than it really is...
- The takeoff trim and airspeed displays were not highlighted like the power display - making them seem less significant (unimportant) to the pilot.
- Communications - because it really isn't designed to improve communications. Also, it isn't too good for flight maneuvers and stalls, because it still doesn't fly enough like a real aircraft.
- Get rid of attitude display!

APPENDIX C

AGATE Concepts Demonstration Plan

Table of Contents

List of Figures

List of Tables

AGATE Concepts Demonstration Plan for 1997 National Air Transportation Association

1. PURPOSE AND SCOPE

This document describes the requirements, design and schedule for the development of the AGATE Concepts Demonstrator (ACD) for the 1997 National Air Transportation Association (NATA) Convention. The annual NATA Convention is to be held in Ft. Lauderdale, Florida, on March 24-27, 1997.

2. REQUIREMENTS

The functional and performance capabilities required of the ACD for the NATA Convention demonstration are described below, first in terms of general system-wide requirements, and then in more specific system element requirements:

2.1 GENERAL REQUIREMENTS

1. The ACD is to consist of a cockpit mockup with interactive controls and displays incorporating an out-the-window (OTW) visual display. The controls and displays will be interactively synchronized to allow the concept demonstrator to be "flown" as a simulated aircraft and to be used to demonstrate aircraft systems, pilot-vehicle interface, pilot-National Airspace System interface and training concepts.
2. The ACD will be used for public demonstrations of AGATE-related activities. As such, it must accurately represent the efforts of the AGATE project.
3. The ACD shall support demonstration of the following concepts:
   - Pilot primary flight display with three-dimensional graphics presented in perspective on two-dimensional display devices and advanced symbologies
   - Head-up display (HUD) and head-down display (HDD) use, interaction and effectiveness
   - Highway-in-the-sky graphic navigation displays
   - Aircraft and powerplant controls and control-display
   - Advanced training system concepts for training the AGATE pilot

3. SPECIFIC SYSTEM ELEMENT REQUIREMENTS

1. The ACD shall provide the ability to control the simulated aircraft and "fly" the simulator as necessary for demonstration of AGATE control and display concepts. The PFD shall provide a perspective presentation of the scene in front of the pilot and include the "highway-in-the-sky guidance concept. The ACD shall provide both head-up and head-

down configurations of the PFD. The MFD shall provide navigation information on a moving map as well as aircraft systems status.

2. An Operator Control Station (OCS) shall provide control of flight modeling and simulation for the ACD.
3. An Out-The-Window (OTW) Visual System shall provide visual scenes for the cockpit demonstration using the 37" monitor and shall be capable of maintaining a satisfactory display update rate.
4. Single lever power control (SLPC) concepts developed in coordination with the Propulsion Sensors and Controls work package will be used to investigate coordinated control of propulsion for aircraft.

4. AGATE CONCEPTS DEMONSTRATION ELEMENTS FOR NATA CONVENTION

The NATA audience for this demonstration will consist largely of owners and employees of many of the approximately 4100 Fixed Based Operators (FBOs) within the United States. Their interests are in the business operations of the general aviation industry including sales of aircraft and aircraft related products, aircraft services (gasoline and oil, parking, etc.), flight planning, arrangements for destination transportation and lodging, maintenance, and flight training. Their concerns are likely to be focused on the contemporary forces influencing their livelihoods, including opportunities to revitalize general aviation industry sales. There will be discussion at the convention about the activities of the recently launched GA Team 2000 Program, of which both the NATA and the AGATE Project are integral parts. The thrust of that program is a coordinated effort by all parts of the industry to increase the number of new pilot training starts. The major contribution of the AGATE Project is the identification and timely implementation of new technologies and capabilities that will result in a larger percentage of pilot training completions due to substantially greater utility of the aircraft and substantially lower training costs.

The key thrusts of this AGATE demonstration at the NATA Convention are to be:

1. Relationship of the AGATE Project to GA Team 2000
2. Representation of key AGATE aircraft features to reduce cost and increase utility
3. Representation of the benefits and opportunities of the Small Aircraft Transportation System Concept/AGATE aircraft/AGATE training to NATA members.

The scenario for this demonstration is to consist of a brief interactive, simulated flight of an AGATE type aircraft in which:

1. Participants will be provided a very brief introduction to the AGATE Project objectives, a brief demonstration of flight planning using AGATE technologies, and a brief overview of the training they could expect for an AGATE pilot (curriculum using PCATD technologies)
2. Participants will be provided a demonstration of at least one PCATD incorporating a learning objective related to upcoming ACD "flight."
3. Participants will "fly" a planned flight from Denver International Airport to Stapleton Airport using the ACD as a simulated "embedded trainer." The simulation will

incorporate selected AGATE technologies, including advanced path depiction concepts in 2D/3D displays on head-up and head-down displays, and integrated flight control/propulsion control/display concepts.

4.1 INTRODUCTORY BRIEFING

A preflight briefing will be developed and supported with posters and computer graphics illustrating:

- Anticipated business as well as recreational use of AGATE aircraft/SATS
- Anticipated volume of AGATE aircraft use
- Benefits of AGATE A/C/SATS vs. other forms of transportation
- Anticipated ownership/service provider scenarios and opportunities to industry
- Overview of AGATE A/C pilot training concepts (PCATD, embedded training, new cockpit system concepts to reduce training, new concepts for certification of airman, new concepts for record keeping)
- Results of market research to date

4.2 ADVANCED TRAINING DEVICE DEMONSTRATION

A demonstration of a personal computer-based advanced training device (PCATD) is to be conducted that will familiarize participants with the concept of using personal advanced training devices as an integral part of all aspects of aviation training curricula. The PCATD training demonstration will show how task training, repetition, testing and rating against a standard can be used to achieve progress toward some desirable level and can be used to indicate adequate training has been achieved.

An existing state-of-the-art PCATD will be modified and used to demonstrate:

- The use of the AGATE flight control and SLPC devices in conjunction with the AGATE display concepts to be experienced by the participant in the ACD
- The formats of the AGATE PFD and MFD display concepts to be experienced by the participant in the ACD
- The practical utility and cost effectiveness of the PCATD concept in formal training programs and in less formal home-based training

The PCATD will incorporate static screens of the advanced PFD "pathway-in-the-sky" guidance display concept presented in conjunction with presentation in perspective format of the scene in front of the pilot. The PCATD will also incorporate static screens of the various modes of advanced MFD concepts for navigation and aircraft systems management. The video screens to be used in the PCATD demonstration are attached at Appendix A.

4.3 ACD FLIGHT DEMONSTRATION FOR NATA CONVENTION

The flight demonstration portion of the AGATE Concepts Demonstration for NATA will consist of a brief simulated flight in which selected operational procedures are demonstrated illustrating anticipated cockpit system improvements that are the subject of the AGATE Flight Systems Work Package and the AGATE Training Technologies Work Package. The simulated flight will be conducted as though the participants were rehearsing an upcoming flight in an "embedded training system" in which the cockpit of an actual aircraft would be equipped so as to be capable of simulating all aspects of operation of the cockpit systems in flight. This "embedded training system" will be simulated by creating a blacked-out out-of-the-window-scene (as though a black-out screen were pulled over the cockpit windscreen and windows) and providing a simulated head-up display incorporating the path-way-in-the-sky guidance and perspective presentation of the outside scene that would be generated from an on-board data base that includes an aerodynamic performance model of the aircraft.

The following scenario will be implemented, demonstrating issues associated with the use of SLPC, head-up vs. head-down displays, advanced display content and format concepts, distribution of information between the PFD and MFD, datalink vs. voice communications for information transfer, and the effectiveness of PCATD and embedded training concepts:

1. OTW scene appears with aircraft on runway ready for take off for preplanned flight. The initial OTW scene will represent sunny visual conditions. The OTW scene will then be changed to represent an "embedded training system" conditions. A simulated head-up display will then be overlaid on the OTW scene containing all information necessary for IFR flight. Simultaneously, an identical display will be provided on the head-down primary flight display. The participants will be encouraged to experiment with the use of both primary flight displays to obtain the information necessary to fly the aircraft.
2. Participants will advance throttle for takeoff and take off on preplanned "embedded training system" flight, following flight path depicted on HUD PFD, on HDD PFD, and on MFD navigation map display. The flight path will be provided for takeoff and departure from Denver International Airport with a transition to a GPS approach into Stapleton Airport only a few miles from Denver.
3. Participants will fly approach and landing into destination airport using "pathway in sky" provided on both HUD PFD and on HDD PFD.
4. ACD will then be reset to the beginning of the GPS approach to permit the participants to reaccomplish the approach and landing phase of the simulated flight. The second approach will be used to demonstrate the extent of training of the participants that occured in the initial simulated flight by comparing the comfort level and performance of the participants in the two different approaches.

5. ACD SYSTEM DESIGN

5.1 GENERAL LAYOUT

The AGATE Concepts Demonstrator (ACD), illustrated in Figure 1 below, is a facility that has been created to demonstrate advanced AGATE concepts in a simulated generic AGATE general

aviation aircraft. Physically the ACD consists of a mockup of a small aircraft cockpit with two seats in a side by side configuration enclosed in a metal frame covered with dark cloth. The enclosure is large enough to surround the physical cockpit mockup with room for an observation area.

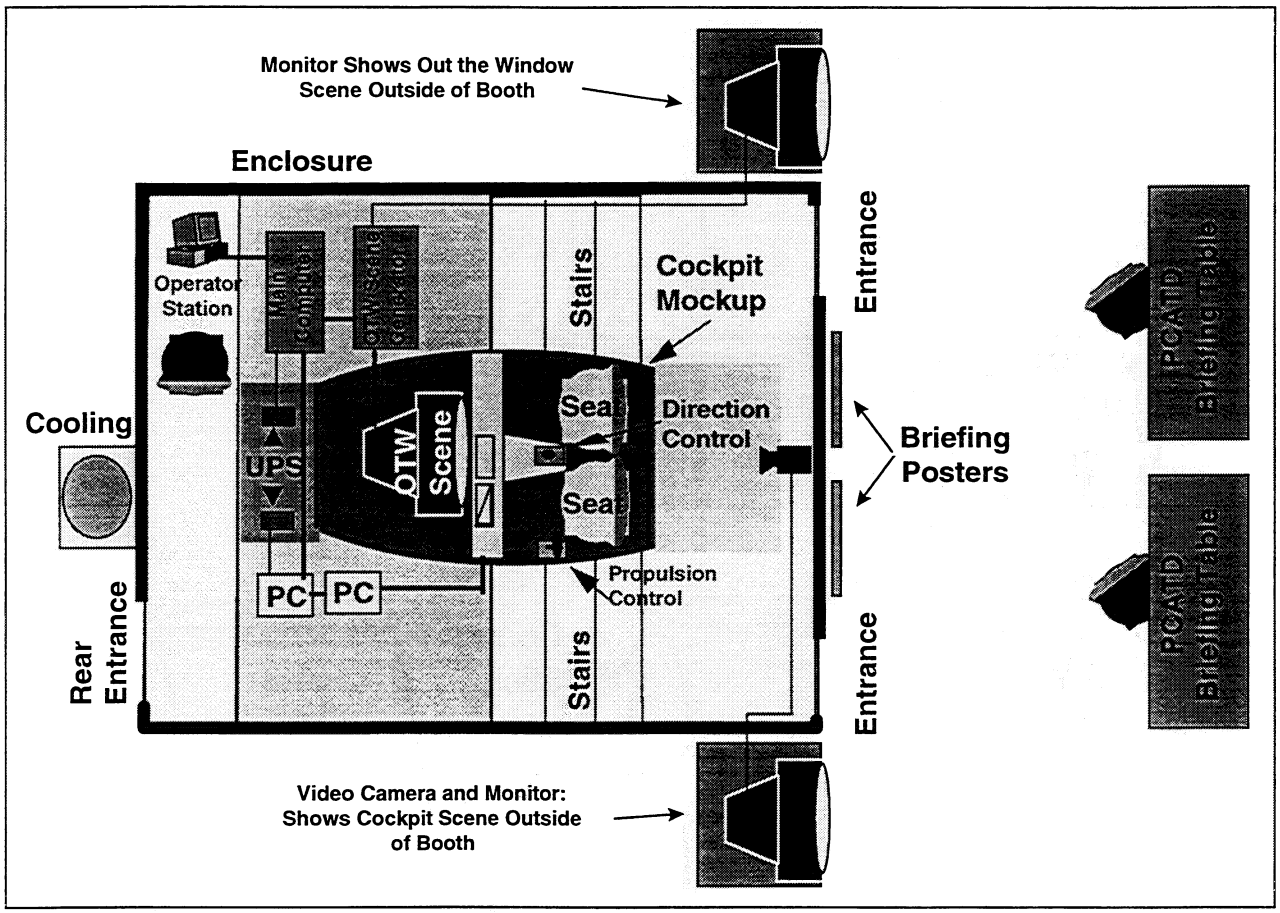

Figure 1 - AGATE Concepts Demonstrator Physical Layout

5.2 PILOT-VEHICLE INTERFACE CHARACTERISTICS FOR NATA DEMONSTRATION

Figure 2 illustrates the general physical layout of the ACD cockpit displays for the NATA convention demonstration. The basic layout includes:

- A side-by-side, horizontal, PFD/MFD presentation
- A head-up primary flight display (HUD) (simulated)
- Head-down PFD and MFD displays tilted appropriately for optimum pilot viewing angle
- A head-down PFD sized to permit its use with perspective presentations of terrain, path, traffic and weather

- A computer data input device for loading the pilot's flight planning and other data
- Controls to fly the simulated aircraft

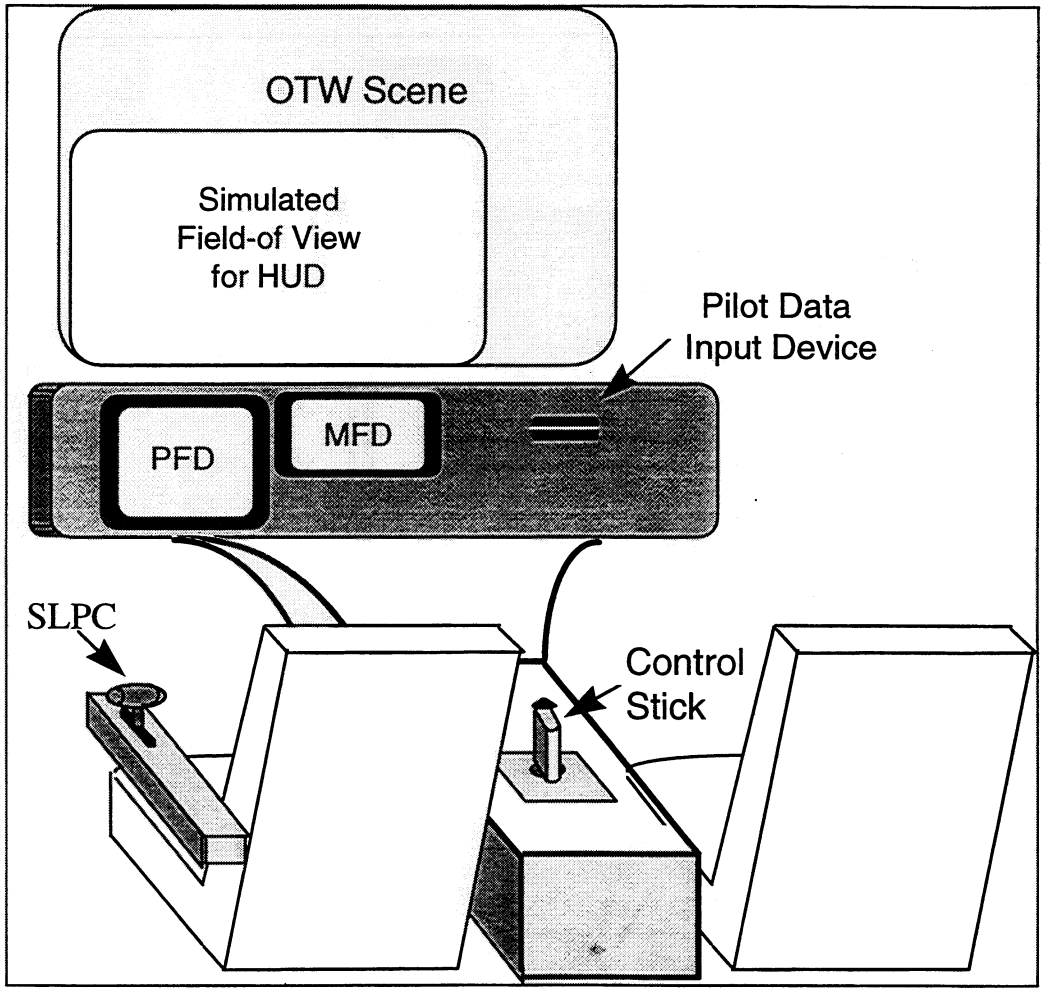

Figure 2 - Pilot-Vehicle Interface Characteristics for NATA Demonstration

5.3 COMPUTER SYSTEM COMPONENTS

The following sections describe the major components and primary interfaces for the computer system architecture of the ACD. The major components and interfaces of the ACD are identified in Figure 3.

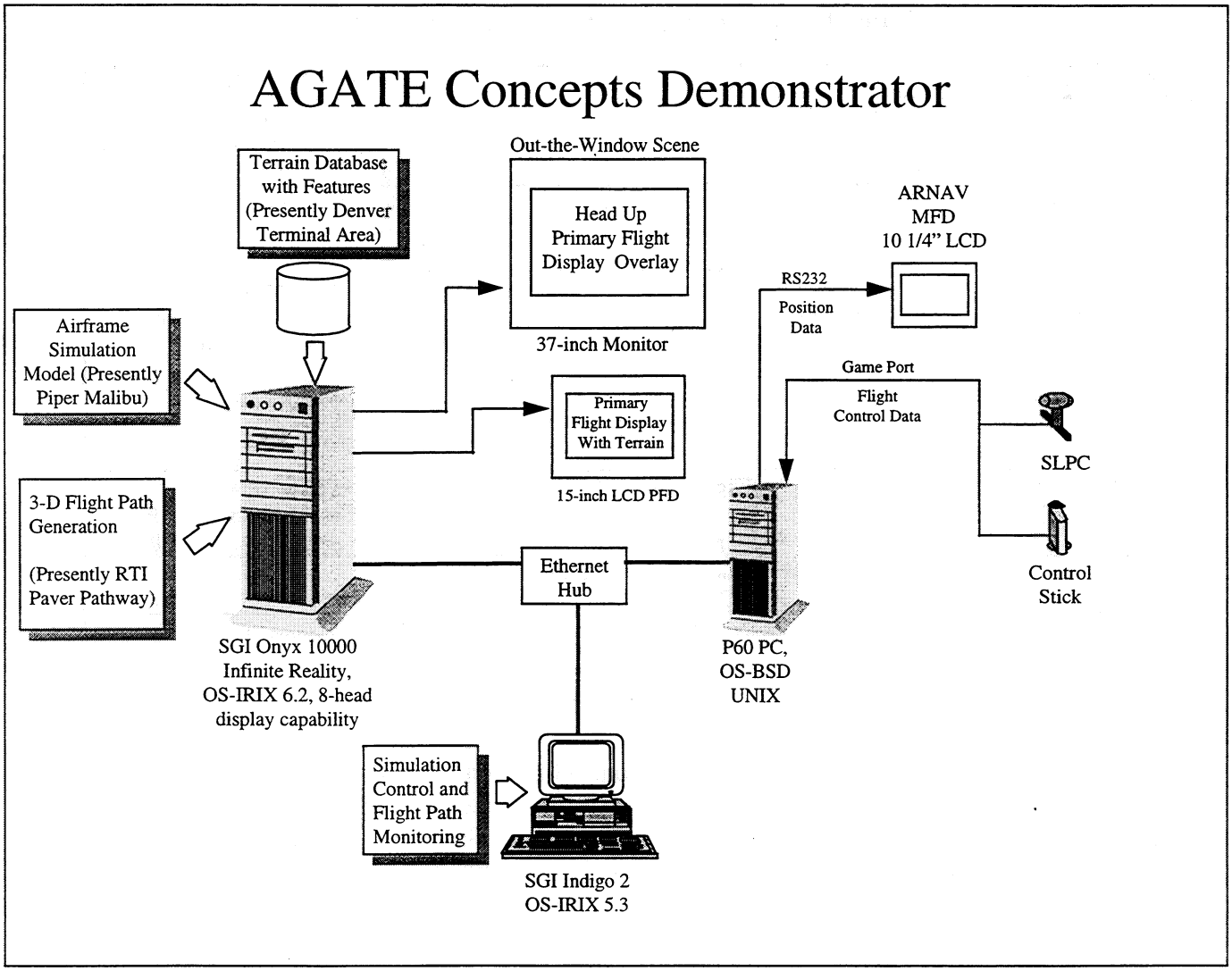

Figure 3 - AGATE Concepts Demonstrator Components and Interfaces

Further description of each of the six major components that comprise the ACD is provided in Table 1.

Table 1 - ACD Computer System Architecture

Component Name	Configuration	Functionality
Operator Control Station (OCS)	SGI INDIGO with: • Color Monitor • CTA Simulation Systems MSS	Simulation control, flight modeling, scenario generation, and data recording
Out-The-Window (OTW) Visual System	SGI ONYX Infinite Reality System with 37" Mitsubishi color monitor	Displays out-the-window visual scenes
Flight Controls and Displays I/O (FCDIO) System	Pentium PC with • 8 MB RAM • 500 MB hard drive • 3COM Ethernet card • 15" color monitor • ThrustMaster ACM Game Card • Free BSD UNIX	Routes pilot inputs from the Flight Controls to the ONYX A/C simulation model
Flight Controls	ThrustMaster Pro Flight Control System ThrustMaster Weapons Control System Mark II	Serve as demonstrator control stick as demonstrator SLPC Serves as demonstrator SLPC
Flight Displays	One 15'' Liquid Crystal Display System One 10 1/4" Liquid Crystal Display System	Serve as the PFD Serve as the MFD
Ethernet Hub	5-port 10BaseT Ethernet mini-hub	Provides connectivity for the OCS, visual scene generator and FCDIO

The Operator Control Station (OCS) acts as the controlling element of the ACD simulation. It communicates with the other components via a 10BaseT twisted pair Ethernet cable. A Silicon Graphics (SGI) INDIGO computer hosts the CTA Simulation Systems, Inc., Mission Simulator System (MSS) software. The MSS provides simulation control, scenario generation, and data recording for the ACD. A 19" color monitor is used for the OCS display.

The OTW Visual System implements visual scenes generated by the SGI ONYX computer displayed on a 37" Mitsubishi color monitor. This component is connected to the other components of the architecture via a 10BaseT twisted pair Ethernet cable.

The Flight Controls and Displays Input/Output (FCDIO) System accepts inputs from the Flight Controls and provides the data to the flight model in the ONYX computer. It is a Pentium-based PC incorporating the FreeBSD UNIX operating system. The PC is configured with a ThrustMaster ACM Game Card that is connected to the Flight Controls. A driver residing on the FCDIO accepts these inputs and translates them into Ethernet packets for transmission to the ONYX computer.

The Flight Controls include the following.

1. ThrustMaster Weapons Control System (WCS) Mark II - This element acts as the Single Lever Power Control.
2. ThrustMaster Pro Flight Control System (PFCS) - This element provides a joystick-like control which replaces the control wheel and column of normal aircraft.

One 15" LCD unit is used for the PFD. A 10 1/4" LCD is used for the MFD.

5.4 PRIMARY INTERFACES

There are five primary interfaces identified and described as follows.

1. OCS-to-Ethernet Hub — The OCS is connected to the Ethernet Hub via a 10BaseT twisted pair Ethernet cable. This allows for the OCS to send position and rate information to the OTW Visual System and the FCDIO. It also is used to accept control inputs from the simulator user through the FCDIO.
2. OTW Visual System-to-Ethernet Hub — The OTW Visual System is connected to the Ethernet Hub via a 10BaseT twisted pair Ethernet cable. It accepts position and rate information from the OCS through this interface. It provides height above terrain and collision detection back to the OCS.
3. FCDIO-to-Ethernet Hub — The FCDIO is connected to the Ethernet Hub via a 10BaseT twisted pair Ethernet cable. This allows for the Flight Control inputs to be sent to the OCS. The FCDIO also accepts Flight Display information from the OCS over the Ethernet. The protocol for this interface is a tailored MSS Remote Message Interface.
4. FCDIO-to-Flight Displays — The FCDIO is connected to the PFD and MFD LCD display systems through a serial communications port. This port is configured as a standard RS-232C interface using a DB-9 male connector. Navigational data is transmitted to the display system to aid in the presentation of situational and status information.
5. FCDIO-to-Flight Controls — The FCDIO is configured with a ThrustMaster ACM Game Card that accepts inputs from the suite of ThrustMaster controls identified in the Primary Components section above. As shown in Figure 3, these controls are daisy-chained together to the game card port. In addition, the WCS Mark II is connected in line with the keyboard of the FCDIO PC (not shown in Figure 3).

6. SPECIFIC TASK ASSIGNMENTS

The specific tasks and organizational responsibilities required to accomplish the responsibilities identified herein for the 1997 NATA demonstration follow:

1	Establish requirements for, design, and make all modifications required to ACD to support 1997 NATA ACD Plan. Operate ACD in support of AGATE Project Office Demonstration at 1997 NATA convention.	RTI
2	Provide modifications to MSS required to operate with new ONYX computer and its operating system	RTI
3	Support RTI in modifications to ACD software and hardware required to support 1997 NATA demonstration	CTA
4	Provide logistics planning and support for demonstrations at NATA convention	NASA

7. VIDEO SCREENS USED IN PCATD DEMONSTRATION

Figure 4 Example of current state-of-the-art electronic Primary Flight Display.

Figure 5 Example of limitations in use of today's PC technology for perspective PFD presentation.

Figure 6 Example of perspective PFD presentation using soon-to-be-available computer technology. (This screen also used to familiarize participants with head-up and head-down PFD displays used in ACD.)

Figure 7 Example of current state-of-the-art electronic MFD navigation display. (This screen also used to familiarize participants with MFD navigation display used in ACD.)

Figure 8 Example of current state-of-the-art electronic MFD aircraft systems management display. (This screen also used to familiarize participants with MFD aircraft systems management display used in ACD.)

Figure 9 Example of current state-of-art electronic MFD aircraft systems management display with abnormal condition (high oil pressure). (This screen also used to familiarize participants with MFD aircraft systems management display used in ACD.)

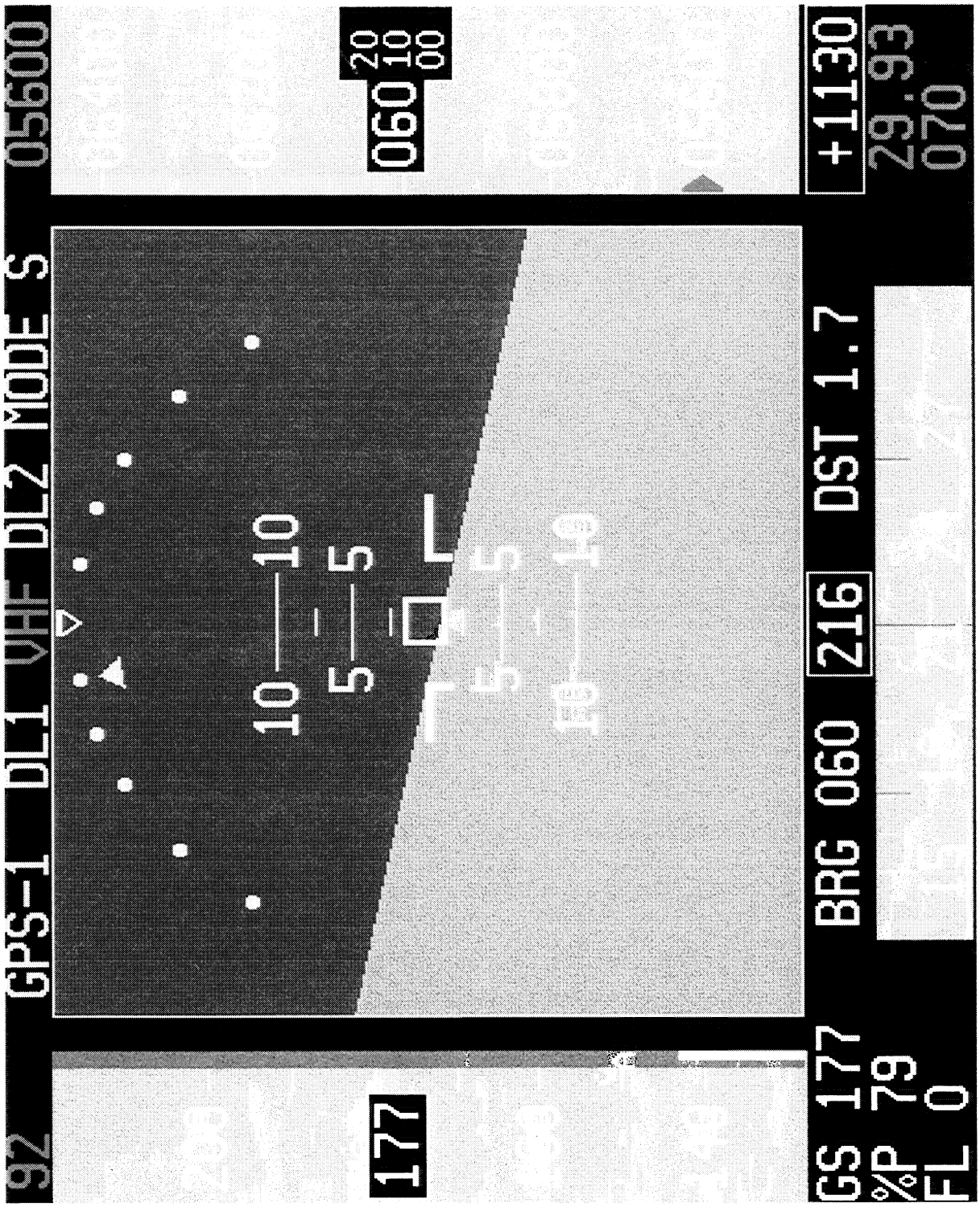

Figure 4. State-of-the-Art Electronic Primary Flight Display

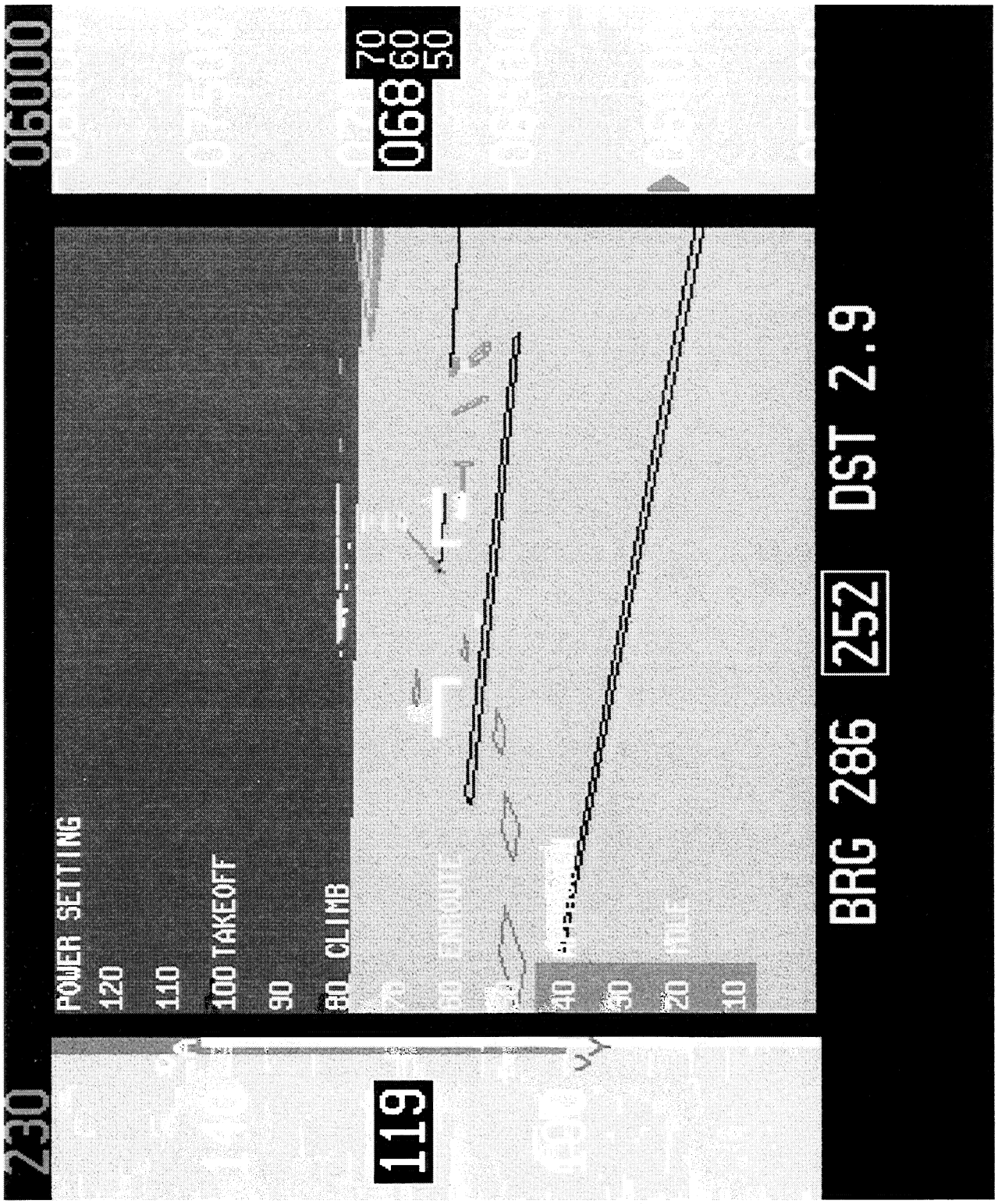

Figure 5. Limitations of Current PC Technology for PFD Presentation

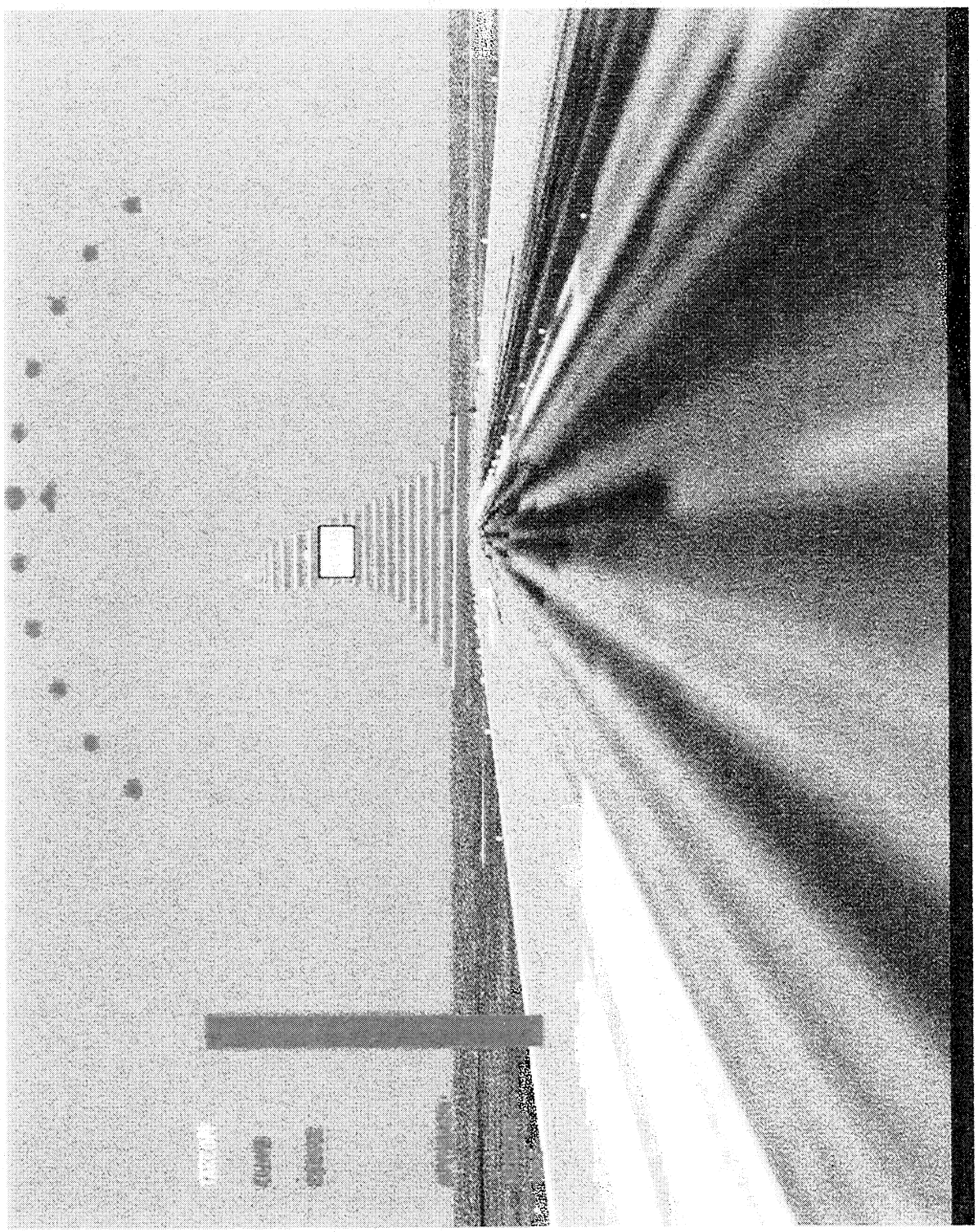

Figure 6. Perspective PFD Presentation Using Soon-to-be-Available Technology

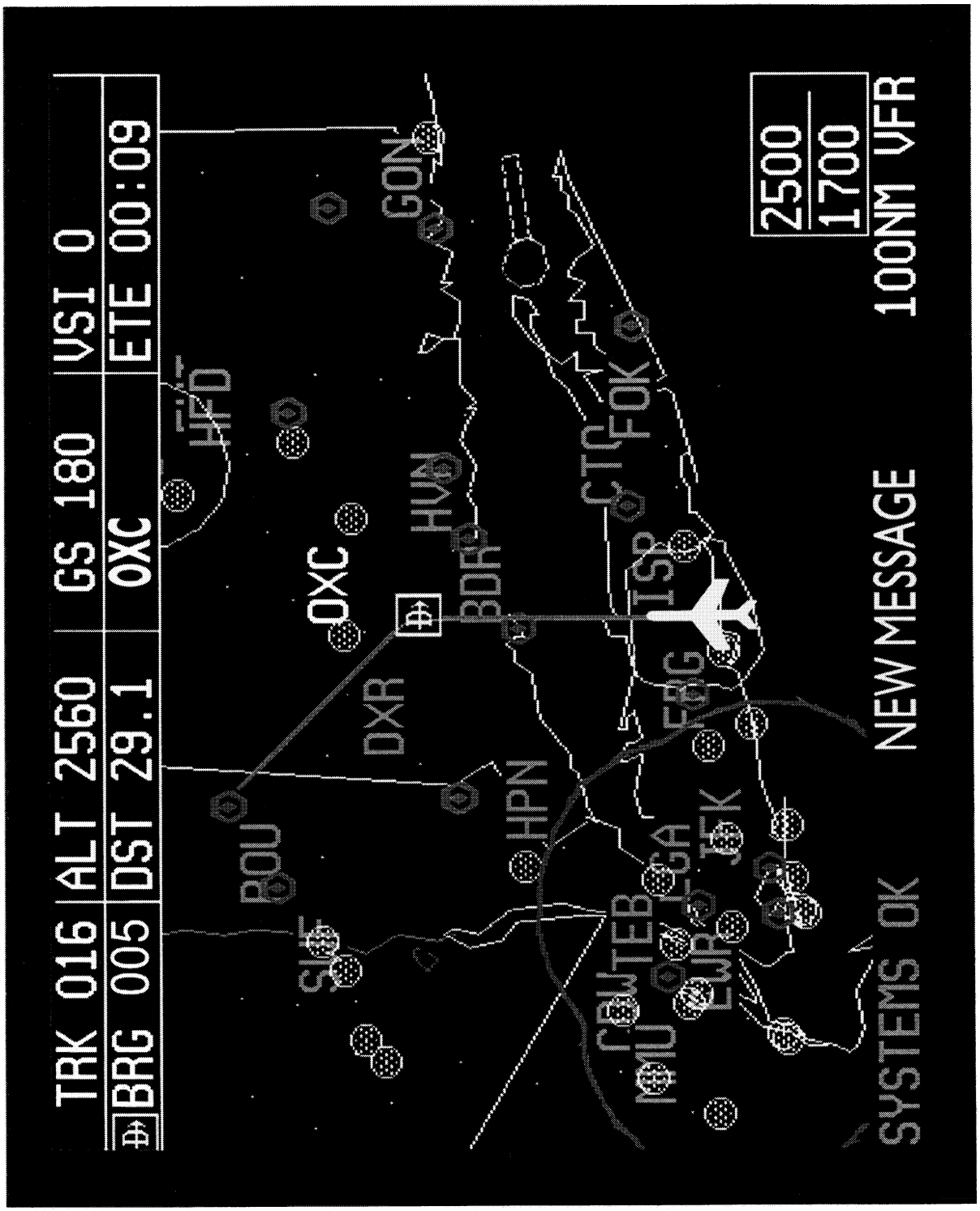

Figure 7. State-of-the-Art Electronic MFD Navigation Display

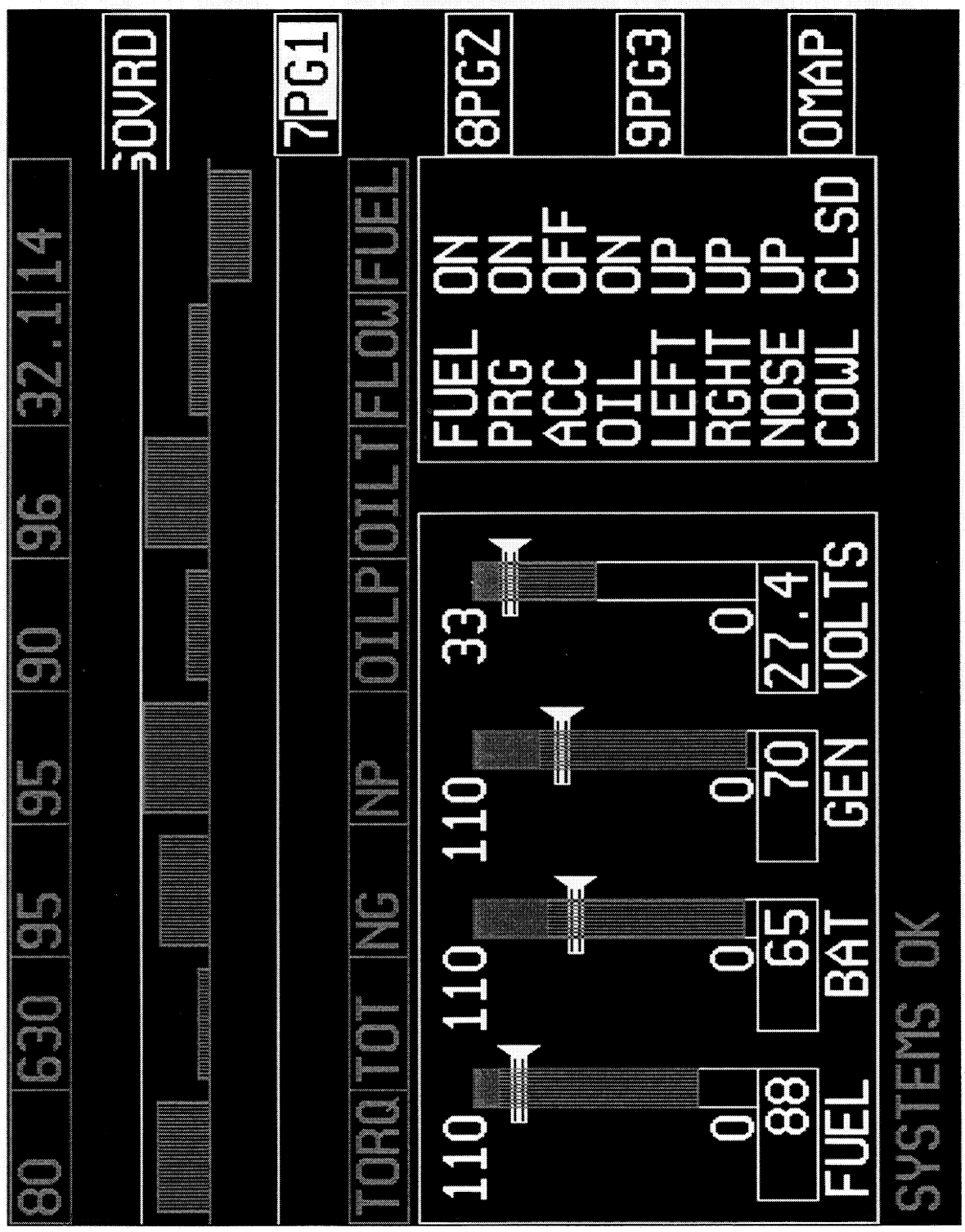

Figure 8. State-of-the-Art Electronic MFD Aircraft Systems Management Display

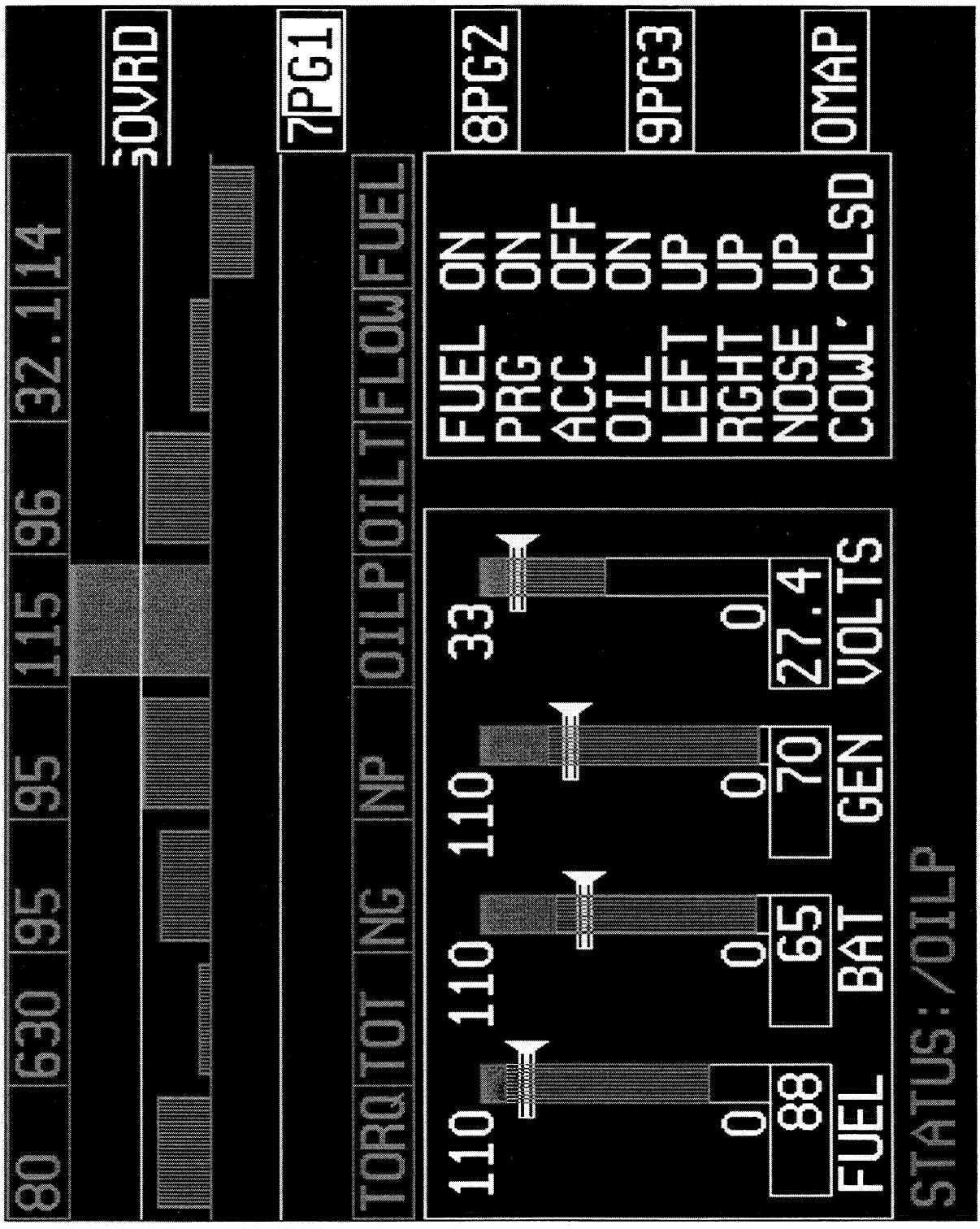

Figure 9. State-of-the-Art Electronic MFD Aircraft Systems Management Display with Abnormal Condition

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 1997	Contractor Report

4. TITLE AND SUBTITLE

Survey Summary of AGATE Concepts Demonstration at Annual NATA Convention Mar. 24-26, 1997, Vol. I - Basic Report

5. FUNDING NUMBERS

NAS1-19214

Task Assignment 21

WU 538-07-19-01

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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Research Triangle Park, NC 27709-2194

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

National Aeronautics and Space Administration
Langley Research Center
Hampton, VA 23681-0001

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

NASA CR-201731, Volume I

11. SUPPLEMENTARY NOTES

Langley Technical Monitor: Daniel J. DiCarlo
Final Report

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Unclassified - Unlimited
Subject Category 01, 03, 85

Distribution: Nonstandard
Availability: NASA CASI (301) 621-0390

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

An AGATE Concepts Demonstration was conducted at the annual National Air Transportation Association (NATA) Convention in 1997. Following a 5-minute introductory briefing, an interactive simulation of a single-pilot, single-engine aircraft was conducted. The participant was able to take off, fly a brief enroute segment, fly a Global Positioning System (GPS) approach and landing, and repeat the approach and landing segment. The participant was provided an advanced "highway-in-the-sky" presentation on both a simulated head-up display and on a large LCD head-down display to follow throughout the flight. A single-lever power control and display concept was also provided for control of the engine throughout the flight. A second head-down, multifunction display in the instrument panel provided a moving map display for navigation purposes and monitoring of the status of the aircraft's systems. An estimated 100 people observed or participated in the demonstration, and 68 surveys were collected. The pilot ratings of the participants ranged from student to Air Transport Rating with an average of 6089 hours total flight time. The overwhelming response was that technologies that simplify piloting tasks are enthusiastically welcomed by pilots of all experience levels. The increase in situation awareness and use of the head-up display were universally accepted and lauded as steps in the right direction.

14. SUBJECT TERMS

Interactive simulation of single-pilot, single-engine aircraft, single lever power control and display concept, moving-map display

15. NUMBER OF PAGES

56

16. PRICE CODE

A04

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified		

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102